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REPORT

on

THE SALTON BASIN IRRIGATION PROJECT

by

C. R. ROCKWOOD

Chief Engineer

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C. R. MOONEY,

Chief Engineer.

STATE OF CALIFORNIA

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To The Colorado River Irrigation Co.,
John C. Beatty, Genl. Manager,
New York.

Dear Sir:

I beg to submit the following report upon the project of irrigating that portion of the Colorado Desert, known as the Salton Basin. I desire to state here, that my data is yet incomplete and that farther investigations will probably change my views upon several points of interest and importance, but in general I can assure you that the deductions and estimates of cost as shown herein, are amply safe.

In the investigation of any irrigation proposition, there are four main features to be examined and considered, viz. Lands, Water Supply, Engineering and Commercial. I will discus these features in the order named.

The Lands

(Refer to map marked Exhibit A)

Location and Acreage.

The lands to be irrigated, are divided by a political line into two divisions, one, containing about 800000 acres, is situated in Lower California, Mexico, and the other, containing about 1250000 acres, lies in the extreme Southern part of the State of California, in San Diego County and in that district known as the Salton Basin.

The Salton Basin.

The Salton Basin extends from the Internation line between Mexico and California in a Northwesterly direction to Indio, a distance of about 90 miles, and from the San Jacinto Mts. on the West to hills of drifting sands, and the San Bernardino Mts. on the East. At one time, this basin formed part of the Gulf of California and today it lies below the level of the sea, sloping gradually from the old beach line down to the Salton Sink, 280 feet below. Whether volcanic action, in the narrow strait between Purdy Mt. and Alamo Mocho, raised that portion of the country sufficiently high to shut out the tide waters of the ocean, or whether the process was more gradual, and accomplished by the deposit of sediment which finally filled up that portion of the old Gulf which lies between the Cocopah Mts. and Yuma, is immaterial; I am inclined to think it was a combination of both causes; but the fact remains, that the day caome when the basin was closed against the sea, but not against the Colorado River. Year after year its muddy waters ran into the imprisioned sea, but the deposit of sediment was raised higher and higher in the Delta between the Cocopah Mts. and Yuma. In the tendency to straighten its course, the river channel was forced further to the east, and finally the day came when only the flood waters of the river overflowed the Delta and entered the Basin. Then the imprisioned salt water rapidly evaporated, and the time arrived when the

How Formed.

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ground in the major portion of the basin was exposed, and dry, except during floods in the river, but for many years after, the floods poured in, carrying their enormous loads of sediment which, no longer mixed with the salt waters, were deposited evenly over the surface of the basin, or over that portion of it lying to the south of the Salton Sink. At last the day arrived when the Delta lands were raised so high that even the floods of the Colorado were shut out, danger from overflow had passed, Nature's work was finished and the lands were left for reclamation and development by man. The old beach, following the sea-level line as shown on the map, is still in existence, and naturally you will find around the beach the drifting sands washed up by the waves of the ocean, but for the most part, these sands are above the level of the canals. There is no sand within the interior of the Basin proper and practically speaking, the only waste land between the International boundary and a point about three miles south from the Salton Sink, lies in the Superstition Mts., a small hill of rock and sand, that I suppose one day formed an island in the sea.

Waste lands.

The lands embraced in the Salton Sink are saline; much of the land lying to the west of the Sink is rocky and probably worthless for agricultural purposes. Most of the lands lying to the east of the Sink, and between it and Indio are of good quality, but, being formed from the wash from the hills, are probably not as fertile as the sedimentary deposits further to the south. It is probable that most of the lands immediately surrounding the Sink and to an elevation of 20 feet above its bottom are salt; but this in no way militates against the value of the proposition, for two reasons, first, we will require this area to catch and evaporate our waste and drainage water, second, this area comprises only about 190000 acres, and on the assumption of a total of 1250000acres, leaves 1060000 acres for cultivation. Other small areas of bad land will be found, and it will be impossible for me to render you an accurate estimate of either the good or the bad, until the projection of a complete topographical map, of which I will write later; but I believe I am amply safe in saying that at least 950000 acres of first class lands lie under the canal in San Diego County, and that 750000 acres lie between the Salton Sink and the International boundary. This body, south of the Sink, into which the first canal will be projected, is without exception the finest tract of land I have ever examined. You can stand in the center and look for miles on either side, over a plain smooth as a floor. A slope of 8 to 15 feet to the mile, in one direction only, renders it perfect for irrigation. Being composed entirely of the sedimentary deposits of the river, it contains a sufficient proportion of clay to make it very retentive of moisture and also to allow of the construction of good roads at minimum expense. The soil is very clean, free from alkalies and wonderfully fertile as is evidenced, not only by the luxuriant growth of weeds that have sprung up at times, but by the Analysis of the Colorado River sediment, made by the University of Arizona. I attach this analysis to my report, marked Exhibit B, and refer you especially to Tables 3 and 4. There is neither sage brush nor cactus on these lands and but little vegetation of any description. Near Syperstition Mtn. there is a body of mesquite covering several thousand acres, and along the Salton and New Rivers, several smaller groves are found. In years when the rains are unusually heavy, a species of grass called pepper grass grows luxuriantly; this makes

. Saline Lands

Surface and Slope

Vegetation

Water. good feed for stock, but the absence of water prevents extensive grazing, however several herds of cattle, aggregating some 5000 head, were wintered there in 1892 and 93. Water for domestic purposes can usually be found at depths of from 20 to 70 feet.

Lower California

The lands in Lower California, that are subject to irrigation under the proposed canals, have been formed in a similar manner to the Salton basin tract, namely by the sedimentary deposits of the river. They are all in the Delta of the Colorado River and would be classed as river bottom lands. The water is much nearer the surface, wells being from 6 to 25 feet in depth. There are many lagoons, some of large area. Within twenty miles of the river, the entire tract is covered with a dense growth of cottonwood, mesquite, brush and native grasses. The greater portion of this area is subject to overflow, but many thousand acres are well above the flood levels, and I believe that the difficulty and expense of protecting the entire tract from danger of overflow would be small, on an acreage basis. As a matter of fact, the main branch canals, for the irrigation of this tract, would run parallel with the river, and the banks of these canals would, in most cases, form the only levees required.

Protection from Overflow

Water Supply.

The water for the irrigation of these lands must necessarily come from the Colorado River. There is no other source of supply. I have not yet undertaken to measure the flow of the river, since these measurements, to be of value, must be very complete and correspondingly expensive. The data that I can obtain from the U. S. Govt. Reports is very meagre. I find the following three measurements made by the Wheeler Survey:

Source Quantity

Locality	Date	Flow cu. ft. per second.	Water Surface below high water.
Stone's ferry Nevada,	Aug. 12, 1875	18410	17 feet.
Fort Mohave, Cal.	Sept. 2, 1875	11611	9 "
Yuma, Arizona,	Mar. 20, 1876	7659	10 "

All of these measurements were made at low water periods, and at Yuma, especially, it is impossible to obtain accurate measurements of the flow, since the alluvial sands are of great depth, and a very large percentage of the water must pass through them. It is important, that a very complete gauging of the river be made. Daily measurements of the flow should be taken for a period of at least a year; but, as the Colorado is an International and Interstate stream, this work is peculiarly the prerogative of the Government and I think should be undertaken by it.

Drainage Area.

The drainage area of the Colorado, according to the Report of the U. S. Geological Survey, is 225,000 square miles. The Gila, with a drainage area of 66000 miles enters the Colorado below our headgates. This leaves for our supply, an area of 159,000 square miles the greater part of which lies in the high plateaus and mountain regions of Arizona, New Mexico, Utah, Colorado and Wyoming. It is impossible to approximate the mean precipitation or run off for the entire area, but

Location

Mean Flow

if we assume that a depth of 2 inches over this area, finds its way into the river, it would give a mean flow for the year of approximately 23400 cubic feet per second. I believe that the mean flow for the summer months, when the greatest amount of water will be required, will exceed this, since the greatest flow of the river is during the summer. Ordinarily the river begins to rise in the latter part of March, reaches its high water stage in May or June and then falls gradually, reaching the low water stage in September or October.

High Water Period

In proof of this statement, I append to this report a diagram marked W. S. 2. This diagram was compiled by Mr. W. S. Hawgood, Resident Engineer of the Southern Pacific Company from daily observations of the height of the river at Yuma. I believe that the Colorado river will furnish an ample supply for all irrigable lands that can be reached by its waters, and at the lowest stage it will at least fill two such canals as the one you propose to build.

Quality of Water

In the development of any irrigationenterprise, the quality of the water is of vital importance. Many waters, used for irrigation, hold in solution salines, alkalies, or other substances that are injurious to veg etable growth, while, on the other hand, certain streams carry in suspension and solution available quantities of fertilizing materials, that become a factor of great value in the production of plant life.

Referring again to Exhibit B, the analysis of the Colorado River water, Table 4, it will be seen that the estimated amount of fertilizing materials carried in each acre-inch of water, has a commercial value of 25.2 cents. The acre-inch is a body with a surface of one acre, and a depth of one inch;

It is probable that we shll require a depth of 36 inches for the successful cultivation of the Salton lands, and on this basis, the value of the fertilizing materials deposited on each acre would be $9.07 per annum. As a matter of fact, we shall not give th the lands this entire value, since a portion of the valuable materials will be removed from the canal through sand pumps, which will be mentioned hereafter, but it is probable that 75% of the fertilizers carried in the water will be placed on the lands, and it means this, that the Salton Basin, like the Valley of the Nile, will never require the expenditure of a dollar to enrich an impoverished soil, and you can charge less for your water rental than many orange orchards of California are paying annually for fertilizers.

Engineering Features.

Surveys

The solution of the problem has involved the study of the river and its vagaries, the examination of the general topographical features of over 3000 square miles of territory and the projection of over 300 miles of careful surveys through bottom lands, covered with a jungle so thick, that every step was preceded by

the axe, and thence into the region of excessive aridity with its consequent hardships. It has necessitated intricate comparative estimates of cost on different routes and with different sizes of canal, in order to determine, beyond doubt, not only the most economical size to construct, but which part of the territory should be first developed. The work has been long and expensive, but, in the development of a proposition of this magnitude, you cannot afford to take chances, and I am sure that you are repaid in the assurance that you are on the right road. I shall not give you a detailed report of all preliminary work done, as it would not be very instructive and I presume that the reading of the results obtained together with my recommendations and the reasons why in certain cases, will take up all the time you have to spare. I commenced my surveys ih October 1892. My force consisted, at first, of a well equipped field party of 19 men. Later on, I was obliged to put an additional party of six men on topographical surveys, and finally the failure to find water forced me to organize a party of five men to sink wells ahead of the surveyors. At times my force consisted of 33 men. Transportation necessitated the purchase of 6 wagons and 18 head of horses and mules. The total expenditures chargeable to Engineering expenses from Sept. 1892 to June 1st, 1893 were $27,545.15. Since June 1st, the running expenses have been approximately $1000 a month, but as Mr. Wightman has rendered you exact accounts of all expenditures, I will not enter into details.

Cost of Surveys

In addition to the topographical surveys and minor works of examination, I have projected 304 miles of line surveys, of which exact records are kept, and profiles and maps shown. The line of final location of the main canal has been decided upon, and staked from the Potholes to the East Branch Fork, a distance of 43.4 miles, and thence on the East Branch 15.3 miles, to a point about 10 miles north of the International Boundary. Accurate preliminary surveys are carried from there to Flowing Well, a station on the line of the S. P. R. R.
From the profiles and cross-sections obtained, I have compiled for comparison, estimates of cost on the following different canals or capacities --

	Capy. of canal, cu.ft. per sec.
From the Potholes to El Rio	2000
"	2500
"	3000
"	3500
From El Rio to Mesquite Lake	1250
"	2000
From East Branch Fork to Flowing Well	2000
Hanlon heading to junction with Potholes line	2000

I have given you from time to time most of the detail data involved in the above work, and shall not repeat preliminary detail here, and I only mention the above that those interested may be assured that the conclusions have been reached only after mature deliveration.

As a result of these labors, it has been decided best to take
Heading. the water from the river at the Potholes, some 10 miles above
the town of Yuma. Your Advisory Engineer, Mr. Campbell,
concurs in the opinion that the Potholes is the lowest heading on the
Colorado that can be considered safe. The gates will be located in
rock and it will be impossible for the river to disturb them, or find
its way back of them. The channel at this point is wide, from the
Intake on the California side to the rock on the Arizona shore being
about 6000 feet. The main channel is at present against our propos-
ed Intake, and no records exit showing that it has ever been elsewhere,
but I consider it quite within the possibilities, that at some time in
the future it might work to the eastward and diminish our water supply,
unless measures to prevent are taken. To prevent this, we will be
obliged to construct training works from the Arizona
Arizona rock toward our gates. This work will be built of
Jetty. piles loaded with rock. It will be simple in plan and
cheap in construction, considering its length. Its
eventual cost will be about $50,000.; but the work need not be
undertaken for several years; not until the increasing area and
value of cultivated lands demands increased protection. It will
necessary to do considerable work at the heading, before
Head plans or close estimates of the Intake works can be sub-
Gates mitted. This structure will be the most important one
on the canal, and its foundation must be most thoroughly
tested before final plans can be drawn, nor do I care to submit to you
my plans until they have been discussed by your Advisory Engineers.
The works should be architecturally pleasing and absolutely safe. My
present idea is, that the walls should be of concrete and the gates
of steel so arranged that the water will be taken in, over instead of
under them. On Sept. 18th, 1893, I submitted an estimate of cost for
these works of $30000. The estimate was based on partial plans then
made. I have changed these plans somewhat, and in view of contingencies
which may arise in construction, desire to increase the estimate to
$35000. At the headgates, the bottom of the canal will be at an
elevation of 10.2 feet below mean low water in the river for the month
of March; hence an adequate volume of water will be
No Dam. assured without a dam.

Proposed Dimensions.

Above From the Potholes to El Rio, a distance of 13 miles, the
El Rio canal has been finally located and estimates of yardage
prepared on the following basis, which I recommend for
adoption,

Grade, 0.35 feet in 5000 feet.

Cross-section

Bottom width,	116 feet,
Top "	158 "
Depth	14 "
Top width of lower levee,	10 "
" " " upper "	6 "
Outer slope of lower levee,	2:1
All other slopes,	1.5:1
Maximum depth of water	11 feet.

Carrying capacity,

at 11 feet depth,	3500 cubic feet per second.
" 10 " "	3000 " " " " "

at El Rio, it is proposed to turn back into the river a large portion of the water, and create there a water power for purposes which will be hereafter explained.

Below El Rio

From El Rio to the Salton Basin, such grades and dimensions have been given as will allow the delivery of 2000 cubic feet per second to the lands. These dimensions vary with the character of the work encountered and detail data of all changes will be shown on the profile accompanying this report; but throughout the greater part of its length below El Rio the canal will have a fall of 1 foot in 5000, a bottom width of 116 feet, a depth of 9 feet from top of levee and will carry a depth of 6 feet of water. Width of levees and side slopes will be the same as above El Rio.

Location.

From the adopted heading on the California bank of the river, about 10 miles above Yuma, the canal will swing directly away from the river, reaching in a distance of 1-1/4 miles, an old water channel at the foot of the highland bluffs, which, in general, it follows for a distance of 9 miles. Three miles below the intake, the canal is three miles away from the river and it keeps a mean distance of a little less than three miles from the river, from that point to El Rio, 13 miles below the Intake. At El Rio, the river runs against the California Bluffs and from there to the International Boundary Line, a distance of 3 miles, the canal will approach as near the river bank as safety will permit. To avoid Pilot Knob Mtn. the canal will have to cross the International Boundary Line and enter Lower California at the end of the 16th mile. After crossing the Boundary the canal swings to the West, directly away from the river, keeping in the alluvial bottom lands at the foot of the mesa bluffs, shown on Map A. As shown on that map, the Central canal will run nearly parallel with the International Boundary for a distance of 37 miles, more or less, when it will swing to the North and reenter California. On this route, the length of canal in Lower California will be 42 miles, more or less, depending upon the point where we may finally decide to recross the Line, which point is arbitrary. You will understand that that portion of the Central Canal, lying between the East Branch Fork and Mesquite Lake, is not yet surveyed, and the line, as shown on Map A, is subject to very considerable change. It marks however my present ideas of where the canal will go, and I feel quite sure in stating that it will occupy the present location as marked on the map, unless I find that I can economically shorten it. The country along the route of the Central canal, from the East Branch Fork, to Mesquite Lake, is a smooth plain, unbroken except where the Salton River cuts through it; I have the profile of the Boundary Line from the East Branch canal to Signal Mtn., I have also the exact location and elevation of Mesquite Lake. With this data, which gives me approximately the length of the canal, and exact elevations, I feel that the line, as shown, is not far out of the way and estimates for that portion between the Fork and Mesquite Lake, as given in this report, are amply safe. The exact surveys, instead of being carried on the Central Route to Mesquite Lake, were carried along the East

Branch to Flowing Well; but, in the progress of the East Branch survey, the fact was developed that three main branches, the East, the West and the Central, would be eventually required, and that the Central canal could be constructed for less money than either of the East or West branches, and that it would pass through the heart of the finest body of land and would command an acreage which would be more than ample for the utilization of all the waters of a 2000 foot canal, hence the decision upon the central canal as the one of first construction and the abandonment of the East Branch for the present.

Construction

In construction, the Central Canal will be remarkably cheap, when we consider the great size and length. Were the object to reach and develop the lands in Low California alone, it would be wonderfully cheap on an acreage basis; but the increased length to reach the objective point in the Salton Basin, increases the cost per acre, but still leaves it below the average. In general the canal, from the Potholes to Mesquite Lake, will be in sedimentary deposits of the Colorado River.

Rock. The only rock that will be encountered, is at the heading and in one or two small spurs from Pilot Knob, which I could avoid, but think best not to.

No Sand. There is no pure sand throughout the entire length of the Central Canal.

With the exception of the first two miles from the Intake, and about an equal distance below El Rio to the International Boundary,

Normal Cut the canal will be practically in normal depth of cutting throughout its entire length. By normal depth of cutting, I mean that depth which will give, on smooth ground, the least yardage in excavation required to construct the levees. Normal cutting gives the cheapest construction possible in theory. On this canal, the normal depth of cut above El Rio should be 4 feet, and below the International Boundary 2.2 feet. The normal yardage

Normal yardage. in excavation should be, for each 1000 feet of canal, above El Rio 18070 cubic yards, and below the Boundary 9720 cubic yards. An examination of the profiles, the depths of cutting and the calculated yardages shown thereon, will show you that, for the major portion of the distance, the actual work is less than 15% in excess of normal. From the East Branch Fork to Mesquite Lake, the ground is much smoother than the ground over which the surveys have been projected and exact

Location of estimates calculated.

Heavy work The excavation for the first two miles below the Intake is heavy but it is all in earth, and I am greatly pleased at the showing made there, since when the survey was staked from the Potholes, I naturally expected to be in very heavy cutting for a much greater distance than 2 miles.

From Sta. 680 to 760,9000 feet, we will be obliged to move 458600 cubic yards, 290000 of which I classify as cement; but this involves no engineering difficulties, it is a matter of expense only, and by means of the El Rio power plant, I expect to hydraulic these heavy

cuts at a cost of not to exceed 8 cents per yard. From the 33rd mile to about the 45th mile of the Central canal, a peculiar means of construction will be adopted. Throughout this section there is a range of low hills running parallel with the mesa

Reservoir

bluff, and enclosing a strip of land varying in width but at no point exceeding one and one-fourth miles. There are many breaks in this range of hills, but from exact surveys, I find it entirely feasible to close these breaks and instead of a canal proper, to create a series of small reservoirs. In no instance will any of these reservoir banks exceed 15 feet in height. The aggregate length of these reservoirs from Sta. 1770 of the canal survey to the East Branch Fork is 7.2 miles, and the yardage to be moved in construction is 125578 cubic yards.
To construct a canal instead of reservoirs over this same distance, would involve the moving of not less than 450000 cu. yds., that is, the reservoirs, aside from their value as storage and settling basins, will actually save nearly 325000 yards in excavation. The reservoir system on the Central canal will extend below the East Branch Fork a distance of between 2 and 3 miles, making nearly 10 miles in all. It is safe to assume that the reservoirs vs. canal will save the moving of 400000 yards, which represents, at 12 1/2 cents per yard, a total of $50000.

Drops.

The ground surface, from the 15th mile, falls more rapidly than we can safely drop the canal on an even gradient, since the

Necessity for drops

velocities that such a grade give to the water would destroy the banks, It then becomes necessary to construct a series of low vertical falls, the location and height of which are shown on the profile accompanying this report. There will be nineteen of these

Location

falls between El Rio and the East Branch Fork, sixteen in the canal proper and three in the reservoirs. The canal falls will be from 1 to 3 feet in height while the reservoir falls will be

Height

4, 5 and 6 feet respectively.

Character of Structure

Although it would be preferable to build all such structures of stone or concrete, the long haul on such materials would at present put their cost too high, so that the better policy seems to be to use wood at first, and when in the course of 10 to 12 years the timber works show evidences of weakness, replace

Cost

with more permanent materials. Timber falls will cost from $750. to $1500. each depending upon location and height of fall.

Engineering Obstacles.

From an engineering point of view, there are two principal sources of danger to the canal, obstacles that must and can be met and overcome. First in importance, is the removal from the canal of the immense amount of sand that will be carried through the gates and dropped at the head of the canal; second, the protection of the canal from the overflow and possible enroachments of the

Colorado River.

Between the Intake and the 34th mile, the canal will pass through in the aggregate, about 21 miles of lands that will be subject to overflow during very high floods. To prevent danger to the canal it will be necessary to prevent the flood waters from overtopping the banks and also to prevent the creation of a current along the outer bank. No expense or additional work will be required to prevent the overflow from overtopping the banks as the top of levee will be naturally well above any possible flood level. Still water against the outer bank will do no harm, on the contrary, it would strengthen the bank by decreasing the resultant pressure from the water in the canal. Swift currents against the bank would destroy it by erosion and undermining. This will be prevented by two methods; the planting of willows and thus increasing the resisting power of the bank, and the building of jetties from the main levee to turn the current away from it. There is but one point on the canal where there is much danger from the encroachment of the river's main channel, and that is in the 13th mile, immediately above El Rio, where a length of 100 yards will require strong protection.

Protection from Over-flow

River Encrouchment

While the large percentage of sediment carried by the Colorado is a feature of great commercial value, since it insures the increasing instead of diminishing fertility of the lands, it, at the same time, is the greates and only unusual obstacle that will tend to prevent the successful operation of the canals. While the mean velocity of 2.5 feet per second, which the canal will have, will carry through the canal and onto the lands all of the clays and fine silt carried from the river into the canal, the heavier sands will undoubtedly be deposited in the canal. To prevent its gradual filling up, means must be adopted to remove these sands as rapidly as deposited.

Sediment to get rid of.

The ordinary flushing methods cannot be adopted, as the first and only location where the usual silt-trap and scouring sluices could be successfully used is at El Rio, 13 miles below the head of the canal. A velocity sufficient to carry the heavier sands through this 13 miles would soon destroy the banks, unless some means of protection were adopted, and any protection would be very expensive; and again, the canal, for the first 15 miles, is throughout on the line of least excavation, therefore any increase in the velocity of the water would necessitate a greater depth of cutting and greatly increase the cost.

I propose to handle the sand in the following manner. Immediately below the canal gates a "settling basin" will be constructed. This basin will be merely an enlargement of the canal. Its form and width will be such as to reduce the velocity of the water through it to about 1 1/4 feet per second. The floor of the basin will be 10 feet below the floor of the canal, forming a sand box. While the velocity of 1 1/4 feet will carry through the basin the clays and fertilizing materials that we wish to carry to the lands, it will allow the precipitation of the heavier sands into the sand box. This must be emptied daily and I think the most feasible means will be to use a pump dredger similar in pattern to the Von Schmidt dredger used on Govt. harbor work. To operate this dredger, I propose to use electric power

Settling Basin

Dredgers

to be developed at El Rio and transmitted to the head of the canal. The same power can be used in the operation of our head and regulating gates. I desire to state that I am not yet ready to give a close estimate on the cost of this machinery or of its operation; before I can do so it will be necessary to undertake certain experiments to determine the amount of sand that will be dropped in the basin, and the percentage of the sediment that can be carried through the canal. Until this is done, it is impossible to determine the size of the dredger or power required to operate it. I have included in my estimate an item of $48000 for this purpose. This figure is based upon the cost of machinery working in San Francisco Bay, and I believe is ample to cover our needs.

Electric Power

El Rio Power Plant.

At El Rio, 13 miles below the Intake, the canal approaches the bank of the river. It was decided the most economical plan to construct the canal from the Intake to El Rio with a maximum capacity of 3500 cubic feet per second, and at El Rio to turn back 1500 cu. ft. of this into the river; to carry then, for the present, only 2000 feet from El Rio to the Salton Basin, and to enlarge the canal between El Rio and the Basin when the development of the lands warranted. The question naturally arises then, can the power generated by this 1500 feet, that we return to the river, be utilized to advantage? With the development of the project, undoubtedly manufacturing establishment would be built in the neighborhood of El Rio that would utilize all the power that we could economically generate or spare. At present, the uses to which the power, or a portion of it, could be put, would be in the excavation of the heavy cement hills below El Rio; in the operation of the silt pumps at the head of the canal and in the operation of the pumping plant of the Yuma Water and Light Co. at Yuma, Arizona. The two latter uses involve electric transmission. It is impossible for me to calculate exactly, the power that we shall require in the operation of our silt pumps and head-gates until the plans are finally decided upon, but I think we will need about 100 H. P. We shall not require the use of this constantly, but probably will require it, during the year, for the equivalent of 175 working days of 24 hours. To develop this power, for this time, using wood, will cost not less than $6500. This sum capitalized at 7% is $92,857.

Power for Silt Pumps

The Yuma Water & Light Co. uses about 200 H. P. at an annual cost of development of approximately $22,000. It will cost us to develop and transmit this power to yuma 5/2 miles:

Developing machinery at El Rio for 200 H. P.	$6,000.
Electric transmitting plant,	15,000.
	$ 21,000.

The wear and tear on machinery of this description is light, and the increased operating expenses of the Co. chargeable to the Yuma plant will be very small. $2,000. per year should certainly cover everything. On this basis, a charge of $13,000. per annum to the Yuma W. & L. Co. will pay 50% net on the cost of the plant, and the proposition would be one that they could not refuse.

In the excavation of theheavy cuts below El Rio, I estimate that it will be necessary to move 458601 cu. yds. of material. The original classification and estimate of cost, using ordinary methods, of excavation, was,

Earth,	168,331	cu. yds.	at	12.5 cts.	21,041.37
Cement,	290,270	" "	"	40 "	116,108.00
					$ 137,149.37

By using the El Rio power, I estimate that these cuts can be removed at a cost of 8 cts. per yard, or a total of $36,688.08; this represents a saving of $100,461.29. In this figure of $36,688, I consider the

depreciated value of the hydraulic or other excavating machinery, but do not take into account the original cost of the Power and Transmission Plant, which is properly chargeable to account of silt works or Yuma power. My proposal then, is to construct the canal from the Headgates to El Rio and put in a power plant at El Rio capable of developing 500 H. P.; to transmit to the headgates all power required there and to use the surplus, probably 400 H. P., first in the excavation of the El Rio Hills, which all lie below the proposed power station, then when this work is done, to transmit 200 H. P. to Yuma, and hold the balance in reserve for other uses that will develop. My estimate of the cost of the power and transmission plant is:

Turbines and connections for 500 H. P.	8,000.
Excavation for wheel pits,	800.
Foundation and walls	4,000.
Power house	1,000.
Labor of setting machinery	1,200.
El Rio transmission plant	20,000.
Yuma " "	15,000.
	$ 50,000.

In addition to the $100,461. saved in excavation, the possible income from this investment, represented in saving to the Co. and in rental of power, is;

100 H. P.	Silt pumps and agates	6,500.
200 H. P.	Yuma W. & L. Co.	13,000.
200 H. P.	Rent to small users at El Rio	26,000.
		$ 45,500.

Cost of operation,

Labor,	3,500.	
Repairs,	2,000.	
Depreciation, 5% on $40,000.,	2,000.	7,500.
Net,		$ 38,000.

I consider these figures merely as an approximation; a close estimate cannot be given until all plans are perfected. The amount of water required to develop 500 H. P. will vary with the elevation of water surface in the river. Ordinarily we will need about 250 cubic feet per second. The table marked "W.S.1" gives the mean working heads for each month in the year.

Side Drainage

In most canals, the problem of taking care of the drainage from the hills and back country is a very considerable one, necessitating the expenditure of large sums of money. Here the expense and danger will be reduced to a minimum, on account of the very light precipitation. The topography of the country is such that there are no large areas collecting into one stream and the soils of the mesas above the canals, being mostly sand, they readily absorb the rainfall. Ordinarily, the water from the hills will be admitted into the canal through an opening in the upper levee. Near El Rio however, we will cross two drainage channels where I think it will be best to construct works to carry the water over the canal and into the river.

Salton River Flume

The only flume required on the canal will be in crossing the overflow channel, known as the Salton River. Greater study of the topography in that neighborhood may prove it best to construct an unbroken bank across the Salton River and force any overflow back into Jululu Lake or New River channel, but my present idea is to flume the river and allow the overflow to follow its natural channel down to Mexquite Lake and Salton Sink, and in this view I have allowed an estimate of $20,868. for this crossing.

Mesquite Lake (reservoir)

As shown on the map, the location of Mesquite Lake is nearly in the center of the irrigable lands south of the Salton Sink. It is merely a natural depression in the country and only contains water when filled by the overflow of the Salton River. It can either be drained at slight expense and used for agricultural purposes or by constructing a low levee at its lower end, a permanent reservoir may be created. It is impossible for me to estimate the cost of this levee or the amount of water that could be stored, until surveys are projected to determine both. Roughly I should think that at moderate expense, we can create a reservoir here, 8 x 3 miles in extent, that will hold 12 feet of water. I think without doubt its value to the Co. will be much greater as a reservoir than as agricultural lands, and would urge that I be allowed to project the necessary surveys and take immediate steps to secure title under the Act of Congress, dated March 3rd, 1891, which grants to canal companies the lands required for storage purposes. The necessity of doing this at once is to prevent settlers from taking desert or homestead claims within the limits of the reservoir.

Distributary canals and drainage water.

In the development of a large irrigation project, although the construction of the main canal will form the largest item of expense, the laying out of the distributary system of canals is or should be, the greatest problem for the engineer to solve. Under many systems, all but the principal branches are constructed by the irrigators, but whether built by the irrigators or the Company, the system must be laid out by the Company, and the smaller ditches built on lines definitely located by it; this

is necessary in order to insure the greatest economy in the use of the water, in the construction of the ditches themselves and that perfection in the working of the whole which will insure to the irrigator and to the Co. the greatest return on the money invested. The distributary system on most of the large works in this country has not been planned as a whole; when a farmer or settlement required water it has been carried to them without reference to the ultimate needs of the whole country under the canal; as a result enormous amounts of money have been wasted in the construction of works, which when completed are found expensive and ineffective in operation. It is seldom that proper attention has been given to the future drainage of a country under canal, the projectors seemingly losing sight of the fact, that ultimately, irrigated lands will fill with water, and that then extensive and expensive works must be projected to prevent the ruins of cultivated farms. The result of this policy is seen in many parts of California to-day, where large areas have become water-logged and ruined through inability of thefarmers to cope with the drainage problem. The drainage system and distributary system should be planned as a whole; it need not be built complete at one time, on the contrary, its construction may extend through a period of years, and need be built only as the development of the lands require; but when any section or settlement is furnished with water, the ditch when completed, should fit into a well planned system and not be a patch on a crazy quilt. In order to lay out the system in the most economical and effective manner, it will be necessary for me to prepare a very accurate topographical map. It is impossible for the engineer to solve such a problem without it. I desire to construct a map showing the contours of each difference of two feet in elevation over the entire country to be served. The necessary field work and compilation of such a map will cost in the neighborhood of $20,000, but I can assure you that it will return its cost many fold before the system is complete. I have included in the estimate of engineering expense, $20,000. for this purpose, and suggest thatthis part of the work be started as soon as the franchises of the Company are secured and line of action definitely settled. Any attempt to estimate the cost of the distributary and drainage system, until it is planned, would be no more than a guess, the accuracy of which would be dependent upon the knowledge of the country and experience in similar countries.

Topographical Map Necessary

On account of the smoothness and character of the soil in the country under the first canal, I thin $1 per acre, or $400,000 should be ample to build all ditches that the Company would construct; but whether it is more or less, is not very material to you at the present time, since the cost of the distributary system is not involved in the amount necessary to raise on stock or bonds in order to put the plant on a self supporting basis. The system will be built, only as the lands are developed, and will be paid for direct out of money derived from sale of lands or water rights.

The Salton Sink.

In discussing the drainage question, I desire to speak more fully regarding that tract of land lying in the bottom of the Salton Basin and known as the Salton Sink. As the major portion of the Basin is below sea-level, it is evident that the surplus and drainage waters cannot be returned to the river or to the Gulf; they will necessarily find their way to the bottom of the Basin from which they can only be removed by evaporation. The salt lands in the bottom, comprising the tract known as the Sink, extend from an elevation of 250 feet below sea-level to an elevation of 280 feet below, and aggregate 190000 acres. The acreage in the extreme bottom, or lying at the 280 ft. level, is approximately 100000. The yearly evaporation in this section has never been fully determined. Experiments elsewhere, where the conditions are similar, leads to the belief that it will approximate 100 inches. Let us assume it to be 96 inches or 8 feet. The entire inflow of the canal, for a period of ten months, would cover this area 12 feet in depth were it not for the evaporation, which being 8 feet, would leave 4 feet of water at the end of the year. As the elevation of the water surface rises however, the evaporation area increases rapidly. A depth of 30 feet of water would have a surface covering 190000 acres. The evaporation from an area of 150000 acres would equal the entire inflow of the canal, and inasmuch as only a small portion of the canal water will find its way into the sink, it is evident that our evaporation surface is ample for all possible needs. I think it would be very beneficial to the country if it were possible to maintain a depth of 15 or 20 feet of water in the sink, as the evaporation would have a tendency to cool the atmosphere.

Duty of Water

By "duty of Water" is meant the acreage that can be irrigated by a given quantity of water, The usual technical term, used in the measurement of water, is the "cubic foot per second", and can be defined as a volume whose end area is one square foot and which moves at the rate of one foot in each second.
No definite statement can be made of the amount of land which a cubic foot per second will irrigate; it depends upon the length of the irrigation season, upon the amount of rainfall, upon the evaporation, upon the texture of the soil, upon the character of the crop to be irrigated, upon the method of applying the water and very greatly upon proper education in the amount required to produce best results. Most irrigators use too much water. The duty of a cubic foot per second varies between 60 and 1000 acres, depending upon the conditions named. In the Salton Basin, the texture of the soil is such that it will retain the moisture remarkably well, and the climatic conditions and water supply are such, that irrigation can be carried on throughout the year, except when necessary to close the canal for repairs, but the evaporation will be very great and the rainfall cannot be depended upon to augment the supply to the lands. Figuring upon irrigation being carried on through ten months of the year, and taking into consideration the supply from our reservoirs as well as the

fact that at no time will the entire acreage covered by water rights be drawing water from the canal, I think you will be safe in considering the commercial duty of the canal as 400000 acres. This is a mean duty of 200 acres per second foot and theoretically admits the placing of a depth of 36 inches of water on the entire tract in the time specified.

Duty of Canal

Loss from evaporation and seepage

In the absence of exact data, showing the evaporation in the Salton Basin, I am obliged to make certain assumptions, which are based upon my knowledge of the climate and upon the experience of other in countries where similar conditions exist. Those who have not studied the subject, usually assume a greater loss by evaporation from the canal surface than really exists. The great loss by evaporation is after the water is turned onto the lands, and is greatly increased by improper methods of irrigation and cultivation. The loss from canal surfaces will seldom exceed 2% of the maximum flow. I give a few statistics, gathered from various scurces, in order that you may have reasonable assurance of the safety of my conclusions.

Evaporation

	Daily Evaporation, Depths in inches.	Authority
India, Ganges Canal.	0.15 mean for year.	Maj. Allan Cunningham R. E.
Northern India	0.5, max. for summer	Dr. Murray Thompson
Spain, Madrid	0.178 mean, 0.435 max. for July	George Higghin M. Inst. C. E.
Northern Italy,	0.083 to 0.20	Baird Smith
Colorado,	0.088 to 0.16	Walter H. Graves, C.E
Utah, Fort Douglas, 1890	0.112 mean, 0.245 Max. for July,	F. H. Newell U.S. Geo. Sur.
California, Kingsburg Bridge	0.126 mean 4 years	State Engr's Dept.
Arizona, Gila Basin (assumed)	0.25 mean 0.42 Max. for Aug.	F. H. Newell

From this data, it would seem that I am amply safe in the following assumptions for our canals, mean daily evaporation, 0.25; maximum 0.75 and mean max. for hottest month 0.6 of an inch. At El Rio, we will return a large volume of water to the river, hence the loss above El Rio does not concern us. The area of the water surface of the main canal, below El Rio, is approximately 43814000 square feet; the area of the branches and distributaries should not exceed 65721000 square feet. On this basis, the loss from the main canal will be:

Mean for year	10.56 cu. ft. per sec.	or	0.53% of full supply
" " hottest Mo.	25.36 " " "		1.27% " " "
Maximum	36.69 " " "		1.58 " " "
The loss from main canal and distributaries,			
Mean for year,	26.40 " " "		1.32% " " "
Mean for hottest Mo	63.39 " " "		3.17% " " "
Maximum,	79.20 " " "		3.96% " " "

The loss from seepage is usually controlled by two factors, the structure of the soil and the amount of silt carried in the water.

Seepage. If the soil is porous, water will pass through it easily, and unless the canal water carries enough clay to eventually fill the voids, the annual loss will be very great, being sometimes as great as 50% of the inflow. I have not, in my experience met with contions more favorable, for the minimum loss from seepage, than here. The canal will be, all the way, in a sedimentary soil of close texture, and the large amount of clay, carried in the water, will soon render the banks impervious. The loss may be considerable for the first year of operation, after that, I doubt if it will exceed 1% of the full supply.

Cost of main canal

The following estimate of cost is an estimate of the actual amount of cash required in the construction fund. In it I assume that the cash will be in the treasury, orforthcoming, when required, that all construction work, including the purchasing of materials and supplies will be under my control, that the canal will be completed within two years from date of commencement of construction, that the present prices of labor and supplies will not change materially and that there will be no material change in the present plans. In general, the plans which are set forth in greater detail in other parts of this report, and in the profiles and data accompanying it, are: that the canal shall have the following capacities:

From the Potholes to El Rio,	3500	cu. ft. per second.
" El Rio to New River,	2000	" "
" New River to Mesquite Lake,	400	" "

That the Intake works and the El Rio wheel pits shall be constructed of concrete masonry; that the Arizona Jetty will be built of Puget Sound piles, loaded with rock; that all other structures will be built of wood, and that where piling is used on the drops, the piles will be of native cottonwood.

ESTIMATE (main canal only)

Grading	(Earth,	4,962,287 cu.yds. at 12/2 ¢	620.285.87		
	(Rock,	49,888 " " 90¢	44,899.20		
	(Cement,	27,696 " " 40¢	11,078.40		
	(At El Rio,	458,601 " " 8¢	36,688.08	712,951.55	
Structures	(Headgates		35,000.		
	(Arizona jetty,		50,000.		
	(Offices & Officers houses		14,000.		
	(S.P.R.R. Bridge		2,500.		
	(Vertical drops,		36,100.		
	(Salton River crossing		20,868.		
	(Stop-gates and wasteways,		8,380.		
	(Patrol and watchman's houses		3,000.	169,848.	
	Clearing, 1600 acres at 5.00			8,000.	
	Protection from overflow			34,382.	
	Telephone line,78-1/2 miles at 50.00			3.925.	
	El Rio power and electrical plant,			50,000.	
	Dredging plant at Intake			48,000.	
	Enginerring expenses			97,250.	
				1,124,356.	
	Add for contingencies, 5%			56,217.	
	Total cash required in construction fund,			1,180,573.	

Cost of System (Capital Account

Main canal, construction fund,	1,180,573.
Loss on 2,000,000 construction bonds at 10%	200,000.
Provision for 2 years interest on bonds at 6%	240,000.
Financiering expenses, say	100,000.
Distributary system, at 1.00 per acre,	400,000.
Chargeable to canals,	$2,120,573

LAND FUND

S. P. R. R. lands, approxly.470,000 acres at $2.50	1,175,000.
Taxes on lands for '94,'95 and '96	15,000.
Interest for 1896 at 6%	70,500.
	$ 1,260,500.

Cash necessary to raise to place the enterprise on a self-supporting basis.

Main canal construction fund,	1,180,573.
Two years interest on bonds,	240,000.
Interest and taxes on lands,	85,500.
Distributary system,	50,000.
Financiering expenses,	100,000.
Safety fund.	143,927.
	$ 1,800,000.

2,000,000 construction bonds at 90 $ 1,800,000.

Commercial features of the enterprise.

The possiblity of rapid development of the country is dependent in the main, upon the ability of the settler to make money and to create there a home that will be conducive to his health and pleasure. Omitting the character and fertility of the lands, which have been already discussed, the principal factors entering into the question are; climate, products of the soil, transportation facilitiesand price charged for land and water.

Climate.

Dryness.

For eight months in the year, the climate is equable and delightful. It is exceedingly dry and physicians report favorably upon it as a sanatorium for invalids, especially those troubled with pulmonary complaints. The summer months are very hot but my own experience, as well as the reports of others, leads me to believe that the heat is not accompanied by the same depressing effect as the moist heat of the East. Sunstrokes are unknown. Those acclimated seem to work in the sun without suffering, when the thermomether in the shade registers 110 deg. The dryness of the air increases the evaporation and cools the body, and a difference of 20 deg. exists between the sensible temperature here and in the East. Personally, I have suffered more with the thermometer at 90 in Michigan than at 110 in Yuma. The summer heat in that portion of the Basin covered by the Central canal is tempered by the winds which every morning blow up from the Gulf. Passing as they do over the dense vegetation of the Delta Lands, the air is cooled, and although I have no temperature records to offer in proof, I am confident that the mean summer temperature in this section is several degrees lower than at Yuma or than any point along the line of the S. P. R. R.

Heat
Sunstrokes
Unknown

Frost.

I do not expect to find this country entirely free from frost, though I think there will be certain belts in it that are practically so, I know of no location is California, where the thermometer has not, at times reached 32 deg. At Yuma, the U. S. Signal Service records show that in the past 17 years, there have been a total of 2 frosty morning in Nov.,6.in Dec., 28 in Jan., 3 in Feb., and 1 in March, the latter being on the 15th day of March, 1891, when 31 deg. is recorded.

In the production of plant life, the number of clear days in the year plays an important part. The Yuma records show, for 17 years an average of 277 clear days, 62 partly cloudy, 12 cloudy and 14 rainy. I annex and make part of this report Meterological Records for Yuma, Salton and Indio. In a study of the temperature records, allow me to caution you to deduct 20 deg. from all summer records and 10 deg. from winter records as I think this is about the difference between the sensible temperature here and in New York.

Sensible temperature vs. Thermometer Records

Products.

I believe the range of products in the Salton Basin will be equal to, if not greater than, that in any other section of California. Its

adaptability to certain products however is a matter that must be proved by actual experience. A very slight difference in climate or soil conditions makes the difference between success and failure in the production of delicate fruits. The Company cannot afford to allow its settlers to make such mistakes, and to prevent such errors, experimental farms should be started by the Co. at the earliest possible time, and an exhaustive study of the soil should be made by some noted agricultural scientist. I would recommend for this work Prof. Hilgard of the University of California.

Experimental Farms.

The products of Yuma and of Indio range from the tropical date and banana down through the semitropical orange and lemon to the ordinary cereal and forage plants of the colder regions. In the river bottom below Yuma, I have gathered ripe wheat of excellent quality, on the 26th of April. Alfalfa, the great forage plant of California, can be grown throughout the entire year and will produce from eight to ten tons per acre. The lemons of Yuma are without exception the finest I have seen. One fact of great value is that the fruits of this section are ripened from two to six weeks ahead of any other section of the state, and are thus insured the first markets and the cream of the prices. I have no reason to doubt but that the Salton Basin will produce all that is now grown in either Yuma, Indio or in any section of California.

Transportation facilities.

At present, the only means of transporting the products of the country to market, is by the S.P.R.R. which traverses the Northern and Eastern part of the Basin. In the development of the country other means of transportation must be considered. The S. P. is too far from the center of development for economical wagon haul, and a branch should be built from their line at some point near Volcano Springs. This branch will be over a smooth unbroken plain. The road can be run due South for any distance required and can be built for the minimum expense of R. R. construction. There will be no difficulty in constructing this road, since a fair interest on the investment could be assured from the start. I shown, on the annexed Prospectus Map B. my idea of the location of this S. P. branch as well as the possible location of the proposed San Diego and Phoenix Road, now in course of construction. Whether this will be built by the Co. now projecting it, is a doubtful question but without doubt it will be built in the near future, and when built, will run through the heart of our country and give us an outlet at San Diego. Although I have never examined the country, I understand that a R.R. running on the dotted line shown as an extension of the S. P. branch, would be in very simple construction all of the way, and that excellent harborage facilities exist at the terminus shown. This is a matter for the future, of course, but the development of the proposition is the work of a lifetime and all possibilities of communication and markets must be of great interest to us. The Gulf road would put our country in direct communication with the Western ports of Mexico and South America and, via the Nicaragua Canal, with the East.

Prices to be charged for land and water

The discussion of this question is perhaps out of place in an engineers report, but as it is the most important question to be decided by the

directors of the Co. and since the welfare of the settler and the profits of the Co. depend upon the correct solution of the problem, I desire to express a few general views. The lower the prices of land and water are placed, the more rapid will be the development of the country and the greater the profit of the settler. This proposition is of such magniture and the conditions of land and water supply so favorable, that the ultimate profits of the Co. are not at all dependent upon the profit derived from the first 100000 or 200000 of land under cultivation. It is my opinion then, that the best policy for the Co. is that which, in the quickest time possible will create a revenue to meet the cost of operation and the fixed charges. If, with this end in view, you sacrifice what you consider your legitimate profits on the first 100000 acres, what of it? You will still have left 300000 acres under the first canal, and when that is gone, the canals can be enlarged to cover 550000 acres more in San Diego County alone.
Your ultimate profits will depend directly upon the financial success of the first settlers, since if they fail you will have to decrease, instead of increase, the price of lands and water. The cultiavation of fruits is expensive; the first settlers will usually be men of small means and for years to come, the principal product of the Basin will necessarily be the grain and forage plants. Semi-tropical fruits and other high class products will come surely but more slowly. Unless the prices of land and water are placed at a figure that will assure a good return from the cultivation of the ordinary farm products, many of the first settlers will fail and your success must depend on theirs. The very magnitude of the proposition necessitates low prices at first. Where other irrigations concerns have needed 100 settlers, you require 1000 to produce the same relative development. To get them, you must offer a proposition that cannot be duplicated in the arid regions, and you can do it and still figure your profits in the millions.

I think that, at first, the prices of land and water rights should be placed at as low a figure as possible, and gradually increased as the development of the country warrants. That the annual rental should be placed at a figure that will pay the cost of maintenance and a reasonable rate of interest on the capital invested, and should never be changed. The lower the rental, the higher you can eventually charge for lands and water rights, and the less danger there will be of conflict with the irrigators and of legislative attempts to lower the rates. I think the cost of maintenance of the system will be in the neighborhood of $150,000 per year. Figuring on a water rental of $1.25 per acre, the total revenue from this source on 400000 acres will be $500000, which will pay the cost of maintenance and 10% on the estimated cost of the canals and still leave a possible surplus of $137943 per annum.

Cost of Maintenance

In California, water rentals vary between $1. and $20. per acre per annum; water rights, between $8. and $200. per acre, and bare land with water rights from $50. to $500. per acre. According to the U.S. Census Report, the average selling price of water rights in California in 1890 was nearly $40 per acre, and of irrigated lands $150. per acre. Judging from my knowledge of the products of irrigated lands in

Southern California and on the Colorado River bottom lands, I think I am sufficiently conservative in making this statement, that at the present time, with an annual rental of $1.25 per acre, a Salton Basin farm, well managed would pay a fair rate of interest on the following valuations:

Cultivated in grains	$50 to $100	per acre.
" " alfalfa	100 to 150	"
" " sugar beets or cane	150 to 200	"
" " deciduous fruits,	150 to 750	"
" " citrus & tropical,	250 to 1500	"
" " general farming	150	"

With this statement, I offer the following figures, which very roughly explain my idea of what should be done and the profits that may be derived from the lands and water rights under the Central Canal.

Possible Profits.

From Central canal, assuming that the water is equally divided between the Company's lands and the Govt. lands;

Govt. Lands	Price of water rights	Total
25,000 acres	$ 10.00	$250,000
25,000 "	12.50	262,500
50,000 "	15.00	750,000
50,000 "	20,00	1,000,000
50,000 "	25.00	1,250,000
200,000 "		$ 3,512,500

Co. Lands	Price of land and water	Total
25,000 acres	$ 30.00	750,000
25,000 "	35.00	875,000
50,000 "	45.00	2,250,000
50,000 "	55.00	2,750,000
50,000 "	70,00	3,500,000
200,000 "		$ 10,125,00

Total receipts from land and water rights	13,637,500
Value of canals, cost price	2,120,573
	15,758,073

Contra	
Expenses of handling the lands, 5%	681,875
470,000 acres R.R. lands at $2.50	1,175,000
Interest & taxes on lands, 10 yrs. estimate	500,000
Cost of Canals	2,120,573
	$ 4,477,448

Profit $11,280,625+ difference between surplus from water rentals and interest on construction bonds.

Enlarged Canals

Although it is impossible, until the surveys are completed, to make a close estimate on the cost of enlarging the system to cover the remaining 550,000 acres of good land in the Basin, I think I am safe in saying that it can be done for $1,500,000, unless it is found necessary to place an expensive weir across the Colorado, in which case the cost may reach $2,000,000. Figuring on this basis and assuming that one-half, or 275,000 acres of the remaining land will belong to the Co. and that the remainder is Govt. land, I offer these figures which you will see are still far below the average price of land and water rights in California,

Water rights on 275,000 acres Govt.land at	$35	$9,525,000.
Co. lands with water, 275,000 acres "	$75	20,625,000.
Value of canal, cost price,		2,000,000.
		$ 32,150,000.

Contra

Expense of handling lands at 5%	1,507,500
Cost of enlarging canals,	2,000,000
	$ 3,507,500.

Profit, $28,642,500 + surplus from water rentals.

Possible Population.

The tendency on all irrigated lands is to small farms and a dense population, and especially is this the case in the warmer climates, where the products are more varied and have a higher commercial value than the products of the colder regions. I think it is a safe assumption that the day will come when the size of the average Salton Basin farm will not exceed 20 acres, On a basis of 950,000 acres, total acreage under cultivation, this would give 47,500 farms, and assuming 5 as the average family directly supported by the farm, gives a rural population of 237,500. If the urban population is 30% of the whole, we may expect eventually, a total population of 339,000, or approximately 230 to the square mile. If we carry out this same ratio for the Lower California lands and assume the acreage irrigated as 640,000, it gives a total population of 569,000 that some day will be dependent upon these canals for their support. This may seem an exaggerated statement, but a study of the statistics of population will convince you that it is not. England has a population of 500 to the square mile, Belgium 535, Saxony 605, France 195 for its entire area of 204000 square miles which includes all of the mountainous and uninhabitable regions, the province of Loire, which contains no large manufacturing city, has a population of 328 to the square mile. The estimated population of the inhabitable regions of India is 400, Massachusetts has 270 and Rhode Island 276. Some of the fruit raising sections of Southern California exceed any of the figures quoted. I am unable to give exact figures, but from the meagre data obtained, I estimate that the population of the Riverside Colony is upward of 700 to the square mile and that portions of the San Gabriel Valley approximate 600. The towns in the basin will eventually draw considerable trade from the mining, grazing and timber industries that will spring up in the adjoining

mountain regions. It is impossible to locate a principle townsite in such a position in the Valley that it can command the trade of the whole, and if you can succeed in carrying through the financial arrangements necessary to the construction of these canals, I most fully believe that some of those connected with the Company will live to see a city of 50,000 inhabitants, somewhere under the line of the proposed canals.

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